IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of: Hang Zhang et al.
Serial No. 10/020,834
Filed: 12/13/01
For: **PHYSICAL LAYER ASSISTED RETRANSMISSION**

Examiner: Haliyur, Venkatesh N.
Art Unit: 2664

Mail Stop Amendment
Commissioner for Patents
PO Box 1450
Alexandria, VA 22313-1450

Sir:

DECLARATION UNDER 37 C.F.R. § 1.131 OF MARK EARNSHAW

1. My name is Mark Earnshaw and I am an employee of Nortel Networks, Ltd. (hereinafter "Nortel"), a wholly owned subsidiary of the assignee of the present application. As part of my obligations as an employee of Nortel, I am obligated to assign any rights to inventions to the present assignee.

2. I am an inventor of Patent Application Serial No. 10/020,834 entitled "PHYSICAL LAYER ASSISTED RETRANSMISSION" (hereinafter "Patent Application").

3. I have reviewed claims 1-5, 7-14, 16-23, and 25-27 presently pending in the Patent Application (hereinafter "Present Invention").

4. At least as early as November 17, 2000, I, together with the other inventors named on the Patent Application, conceived of the Present Invention, as evidenced by the document entitled "Physical-Layer-Assisted Fast NAK for RLP in Wireless Access Networks", and the accompanying screen shot from my computer showing the date stamp of 11/17/2000 for the document having file name "Mark_Fast_NAK.doc", which are attached to this Declaration as Appendix A.

5. My co-inventor Hang Zhang then submitted an Invention Disclosure, redacted to remove personal and confidential information, entitled "Physical-Layer-Assisted Fast NAK for RLP in Wireless Access Networks," which is attached to this Declaration as Appendix B, on November 20, 2000, to the Intellectual Property Law Department at Nortel. The Invention Disclosure was

based on the document attached as Appendix A entitled "Physical-Layer-Assisted Fast NAK for RLP in Wireless Access Networks".

6. The Invention Disclosure and the document attached as Appendix A support conception of the Present Invention at least as early as November 17, 2000.

7. I hereby declare that all declarations made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Mark Earnshaw

Mark Earnshaw

June 13/2006

Date

Appendix A

Physical-Layer-Assisted Fast NAK for RLP in Wireless Access Networks

1. Brief description of the invention:

The objective of wireless access network Radio Link Protocol (RLP) ARQ schemes is to provide improved radio link quality by implementing a retransmission mechanism for non-delay-sensitive services and applications. An IP-aware RLP design allows a RLP frame to encapsulate an IP packet or fragment of a IP packet. Each RLP frame header includes a sequence number to maintain the integrity of RLP frames flowing over the wireless link. In a NAK-based RLP ARQ scheme, after identifying the loss of a RLP frame at the receiver side RLP, a NAK message is sent to the transmitter side RLP. This NAK message triggers a retransmission of the RLP frame by the transmitter side RLP. A lost RLP frame is identified by checking the sequence numbers. For example, the receptions of RLP frame No. n and No. $n+2$ in a row means that RLP frame No. $n+1$ was lost. After receiving RLP frame No. $n+2$, the receiver side RLP sends a NAK for frame No. $n+1$. In a high-speed wireless Internet access system, packet inter-arrival times may be wide-spread due to the high burstiness (non-stream-like nature) of packet applications. If packet No. $n+2$ arrives at the receiver a relatively long time after packet No. n, then the receiver RLP will take a longer period of time to identify the possible loss of packet No. $n+1$. This results in a longer wireless link delay for packet No. $n+1$. Also, for a wireless access system with a shared fat downlink channel, the scheduler can cause a similar problem as described above. For example, the scheduler may schedule packet No. $n+2$ a long time after scheduling packet No. $n+1$ due to the real-time traffic load, scheduling algorithms , etc. This invention investigates a physical-layer-assisted method to speed up the identification of a lost RLP frame and to decrease the delay of RLP frames needing retransmission.

2. Problem solved by the invention:

See above.

3. Solutions that have been tried and why they didn't work:

There are some existing methods to solve this problem.

Qualcomm solution (NAK-based):
After sending a frame, a timer is initiated at the sender RLP side. If the next frame is scheduled before the timer expiration, this timer is reset. Otherwise, upon the expiration of the timer, the sender side RLP transmits a RLP control message which indicates the last octet sent so far (such a RLP control message will be protected with a higher level of reliability than is the data traffic). The receiver RLP then checks if it has received all of the transmitted data. If the last octet in the control message is larger than that in the data which has been received so far, then apparently one or more RLP frames have been lost. This triggers an immediate NAK message. In this way, the receiver side RLP does not have to wait until the next RLP frame's arrival before it knows if any RLP frames have been lost.
The timer value is fixed and is non-QoS based.

Nortel's solution:
After sending an RLP frame, two timers are initiated at the sender RLP side. If the first timer is allowed to expire, it means that the sender does not yet know whether or not the receiver has a valid copy of the RLP frame. An ACK REQ signal is sent to the receiver asking it for the sequence number of the most recent RLP frame received. If no response is obtained before the second timer expires, the sender assumes that the receiver does not have a copy of that RLP frame and retransmits it. The timers are cancelled if the transmitter is able to determine either that the receiver has a copy of the RLP frame in question or will be requesting it via the NAK procedure. Periodic ACK signals may also be sent by the receiver to reduce the overall amount of signaling over the wireless link. The timer values are set according to the desired QoS delay bounds for the data traffic being transmitted.

These solutions improve delay performance. However, there is still some room for further enhancement. The proposed enhancement here is expected to further shorten packet delay for packets which require retransmission.

4. Specific elements or steps that solved the problem and how they do it:

This proposal is a physical-layer-assisted and QoS-based solution and can be used on top of both existing solutions. RLP frames need to be retransmitted in two different situations. In the first case (Case 1, [redacted]), the transmitted RLP frames are totally lost and the receiver cannot detect any signal. In the second case (Case 2, [redacted]), the signal is strong enough to be detected but the detected frame is in error. For Case 2, the physical layer can send a primitive to the RLP and inform the RLP that a damaged RLP frame has been detected. This primitive will trigger an immediate NAK message and in this way, a corrupted RLP frame can be NAK-ed much more quickly than via any of the other solutions. The steps for this proposal are described as follows:

(1) Assumption: user ID information related to each RLP frame can be detected correctly with a much higher level of reliability than for data traffic. This can be accomplished either by using a more robust modulation and coding scheme for greater protection or by each user's particular preamble for forward link demodulation (e.g. Qualcomm's HDR).

(2) Enhancement to Qualcomm's solution: (refer to Fig. 1)
  a. After sending a RLP frame, a timer with a fixed value is set at the sender side.
  b. If the physical layer identifies a corrupted RLP frame, it sends a primitive to the RLP immediately to indicate that a corrupted frame has been identified.
  c. The receiver side RLP sends a NAK and indicates the last octet received so far.
  d. The sender RLP resets its timer and retransmits the lost frame.
  e. If the physical layer cannot detect the retransmitted RLP frame due to severe fading, then go back to original solution: At the timer expiration, the sender RLP transmits a message showing the last octet sent so far.

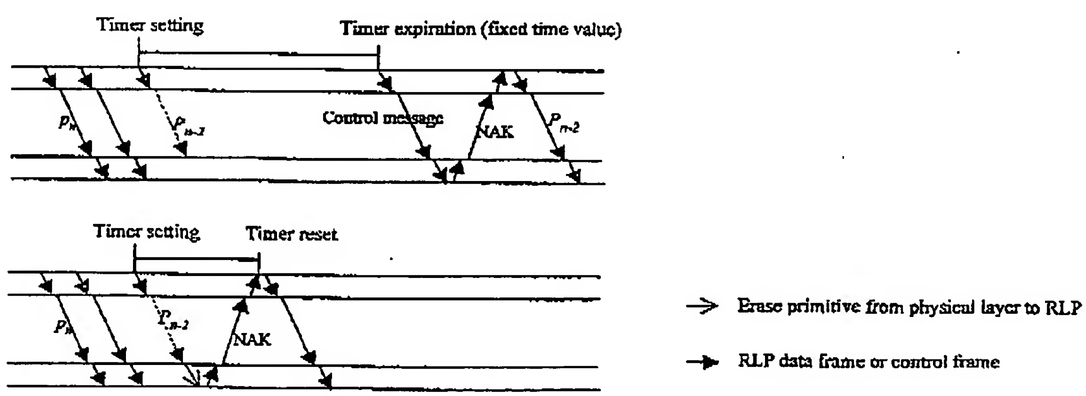


Fig. 1. Enhancement to HDR solution

(3) Enhancement to Nortel's solution: (refer to Fig. 2)
  a. After sending a RLP frame, the sender side RLP sets a QoS-dependent timer value.
  b. If the physical layer identifies a corrupted RLP frame, it sends a primitive to the RLP immediately to indicate that an corrupted frame has been identified.
  c. The receiver side RLP sends a NAK and indicates the last octet received so far.

d. The sender RLP resets its timer and retransmits the lost frame based on the QoS-aware RLP ARQ algorithm

e. If the physical layer cannot detect this RLP frame due to severe fading, then go back to original solution: At the timer expiration, the sender RLP sends a message asking for the last sequence number received so far. The receiver side replies with its last known sequence number and this will trigger a retransmission.

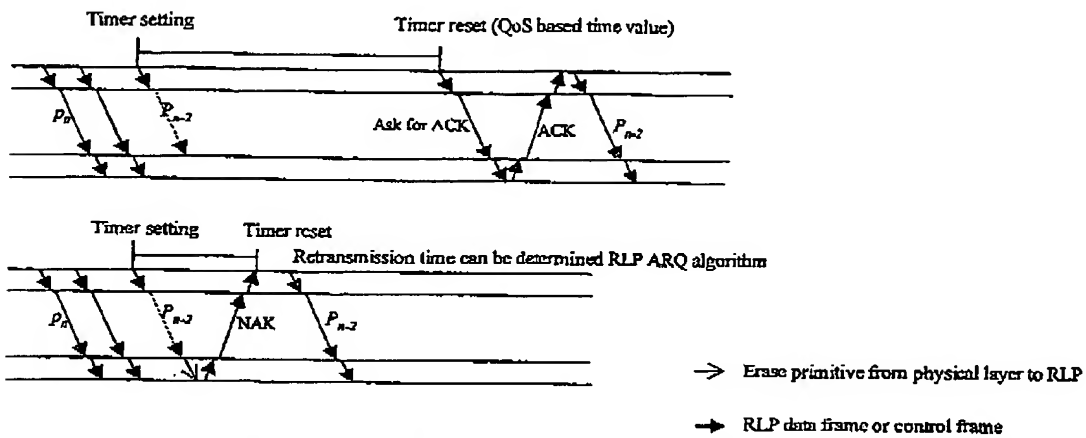


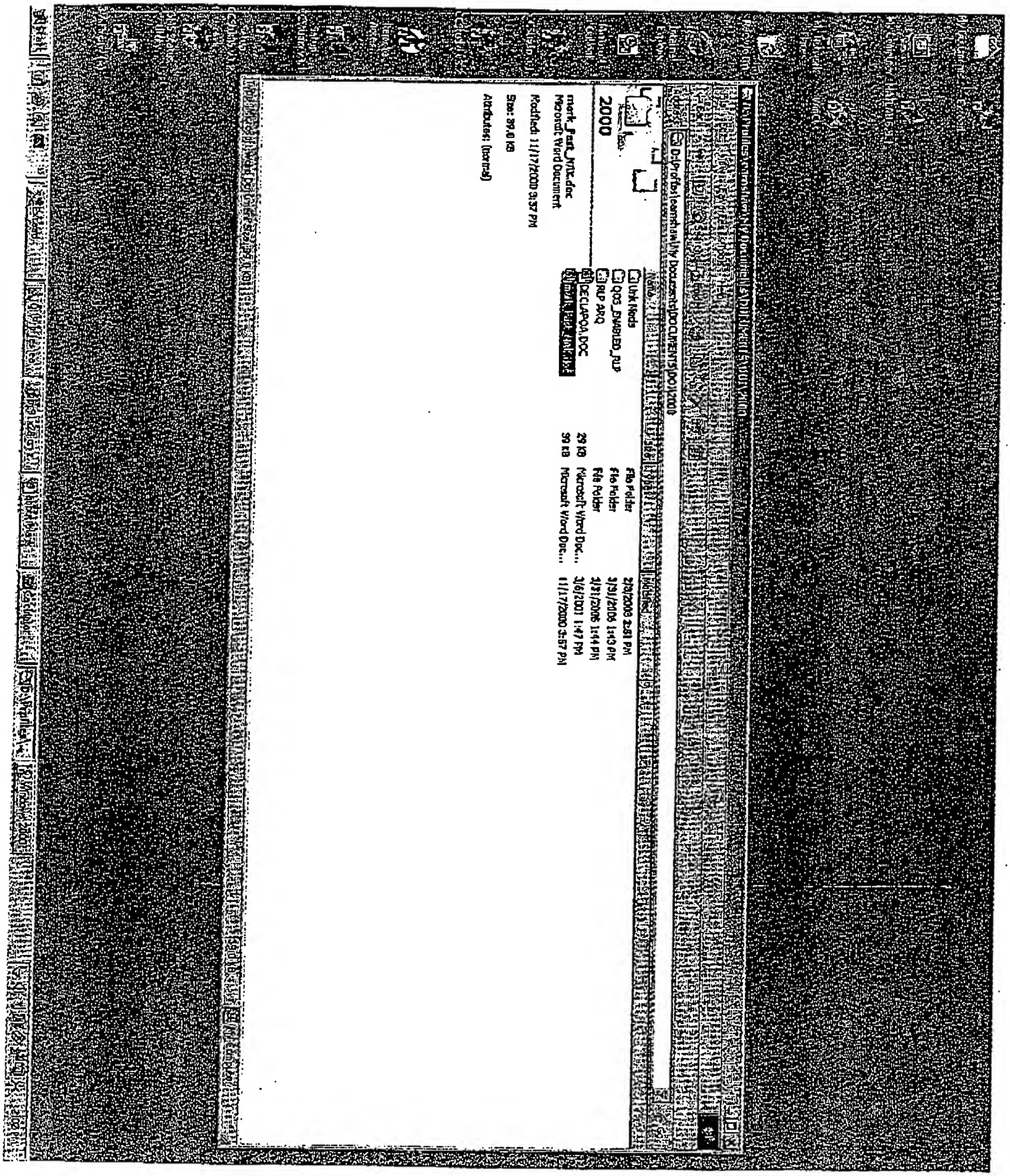
Fig. 2. Enhancement to Nortel's solution

With this enhancement, the net delay of RLP frames which require retransmission can be expected to be shortened. [redacted]

5. Commercial value of the invention to Nortel and Nortel's major competitors:

Technical benefits
- Improves the delay performance of the wireless link, thereby aiding in improving QoS-delay performance.
- Simplifies the signaling procedure for retransmissions, and consequently decreases the signaling message load.

Commercial benefits
- Added value to Nortel's patent profile for current 3G systems and future wireless access systems.
- Contribution to current 3G standards and future wireless access network (e.g., mobile or fixed) standards.



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Appendix B

Nortel Networks Confidential & Privileged Information

SW

Invention Disclosure Submission Reply

[illegible]		[illegible]	20 nov 2000
[illegible]	Physical-Layer-Assisted Fast NAK for RLP in Wireless Access Networks		

Inventors

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Attachments

<End of Attachments>

[illegible]	yes	[illegible]	no
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No.			
[illegible]		[illegible]	
[illegible]			no
[illegible]		[illegible]	
no			

Technical Information

Brief Description of the Invention

The objective of wireless access network Radio Link Protocol (RLP) ARQ schemes is to provide improved radio link quality by implementing a retransmission mechanism for non-delay-sensitive services and applications. An IP-aware RLP design allows a RLP frame to encapsulate an IP packet or fragment of a IP packet. Each RLP frame header includes a sequence number to maintain the integrity of RLP frames flowing over the wireless link. In a NAK-based RLP ARQ scheme, after identifying the loss of a RLP frame at the receiver side RLP, a NAK message is sent to the transmitter side RLP. This NAK message triggers a retransmission of the RLP frame by the transmitter side RLP. A lost RLP frame is identified by checking the sequence numbers. For example, the receptions of RLP frame No. n and No. n+2 in a row means that RLP frame No. n+1 was lost. After receiving RLP frame No. n+2, the receiver side RLP sends a NAK for frame No. n+1. In a high-speed wireless Internet access system, packet inter-arrival times may be wide-spread due to the high burstiness (non-stream-like nature) of packet applications. If packet No. n+2 arrives at the receiver a relatively long time after packet No. n, then the receiver RLP will take a longer period of time to identify the possible loss of packet No. n+1. This results in a longer wireless link delay for packet No. n+1. Also, for a wireless access system with a shared fat downlink channel, the scheduler can cause a similar problem as described above. For example, the scheduler may schedule packet No. n+2 a long time after scheduling packet No. n+1 due to the real-time traffic load, scheduling algorithms , etc. This invention investigates a physical-layer-assisted method to speed up the identification of a lost RLP frame and to decrease the delay of RLP frames needing retransmission.

Problem Solved by the Invention

See above.

Solutions that have been tried and why they didn't work?

There are some existing methods to solve this problem.Qualcomm solution (NAK-based):After sending a frame, a timer is initiated at the sender RLP side. If the next frame is scheduled before the timer expiration, this timer is reset. Otherwise, upon the expiration of the timer, the sender side RLP transmits a RLP control message which indicates the last octet sent so far (such a RLP control message will be protected with a higher level of reliability than is the data traffic). The receiver RLP then checks if it has received all of the transmitted data. If the last octet in the control message is larger than that in the data which has been received so far, then apparently one or more RLP frames have been lost. This triggers an immediate NAK message. In this way, the receiver side RLP does not have to wait until the next RLP frame's arrival before it knows if any RLP frames have been lost. The timer value is fixed and is non-QoS based. Nortel's solution:After sending an RLP frame, two timers are initiated at the sender RLP side. If the first timer is allowed to expire, it means that the sender does not yet know whether or not the receiver has a valid copy of the RLP frame. An ACK REQ signal is sent to the receiver asking it for the sequence number of the most recent RLP frame received. If no response is obtained before the second timer expires, the sender assumes that the receiver does not have a copy of that RLP frame and retransmits it. The timers are cancelled if the transmitter is able to determine either that the receiver has a copy of the RLP frame in question or will be requesting it via the NAK procedure. Periodic ACK signals may also be sent by the receiver to reduce the overall amount of signaling over the wireless link. The timer values are set according to the desired QoS delay bounds for the data traffic being transmitted.These solutions improve delay performance. However, there is still some room for further enhancement. The proposed enhancement here is expected to further shorten packet delay for packets which require retransmission. Timer values in this algorithm are set depending on packet QoS.

Specific elements or steps that solved the problem and how they do it

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This proposal is a physical-layer-assisted and QoS-based solution and can be used on top of both existing solutions. RLP frames need to be retransmitted in two different situations. In the first case (Case 1, representing much less than 1% chance of happening), the transmitted RLP frames are totally lost and the receiver cannot detect any signal. In the second case (Case 2, representing more than 99% chance of happening), the signal can be received but the received frame is in error (user ID can be detected correctly, see assumption (1) below). For Case 2, the physical layer can send a primitive to the RLP to inform it that a damaged RLP frame has been detected. This primitive will trigger an immediate NAK message to the sender and in this way, a corrupted RLP frame can be NAK-ed much more quickly than via any of the other available solutions. The steps for this proposal are described as follows:(1) Assumption: user ID information related to each RLP frame can be detected correctly with a much higher level of reliability than for data traffic. This can be accomplished either by using a more robust modulation and coding scheme for greater protection or by each user's particular preamble for forward link demodulation (e.g. Qualcomm's HDR).(2) Enhancement to Qualcomm's solution: (refer to Fig. 1)a. Upon sending a RLP frame, a timer with a fixed value is set for this RLP frame at the sender side.b. At the receiver side, if the physical layer identifies a corrupted RLP frame, it sends a primitive to the RLP immediately to indicate that a corrupted frame has been identified.c. The receiver side RLP sends a NAK to the sender RLP to indicate the last octet received so far.d. Upon received the NAK, the sender RLP resets timer of that RLP frame. It then retransmits the lost frame and set a timer for the retransmitted frame upon the retransmission done.e. At the receiver side, in case the physical layer cannot even detect a RLP frame due to severe fading, the original solution will kick in to recover the lost: At the timer expiration, the sender RLP transmits a message showing the last octet sent so far. So the receiver will know if there is any RLP frame missing after this message.(3) Enhancement to Nortel's solution: (refer to Fig. 2)a. After sending a RLP frame, the sender side RLP sets a QoS-dependent timer value based on the QoS of the RLP frame.b. At the receiver side, if the physical layer identifies a corrupted RLP frame, it sends a primitive to the RLP immediately to indicate that a corrupted frame has been identified.c. The receiver side RLP sends a NAK to the sender side RLP to indicate the last octet received so far.d. Upon received the NAK, the sender RLP resets the timer of that RLP frame and retransmits the lost frame based on the QoS-aware RLP ARQ algorithm and set a timer for the retransmitted frame upon the retransmission done.e. At the receiver, if the physical layer cannot even detect this RLP frame due to severe fading, then go back to original solution: At the timer expiration, the sender RLP sends a message asking for the last sequence number received so far. The receiver side replies with its last known sequence number and this will trigger a retransmission round.With this enhancement, the net delay of RLP frames which require retransmission can be expected to be shortened. For a lost frame, with a conservative assumption that case 2 happens with more than 99% probability and case 1 happens with much less than 1% probability, the delay performance for packets which require retransmission can be improved in 99% of the retransmission cases. When this proposal is applied to RLP ARQ schemes where the ARQ parameters are fixed (e.g., round of retransmissions and number of copies for each retransmission), this proposal can be flexibly adapted to those schemes. For example, if the number of copies of each retransmission round is no larger than 3, the receiver side RLP will send a NAK only if it receives, e.g., three primitives in row.

Commercial value of the invention to Nortel and Nortel's major competitors

Technical benefits· Improves the delay performance of the wireless link, thereby aiding in improving QoS-delay performance and support multiple QoSs.· Simplifies the signaling procedure for retransmissions, and consequently decreases the signaling message load.Commercial benefits· Added value to Nortel's patent profile for current 3G systems and future wireless access systems.· Contribution to current 3G standards and future wireless access network (e.g., mobile or fixed) standards.